BROMINE

By Phyllis A. Lyday

Domestic survey data and tables were prepared by Maria Arguelles, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

Bromine is one of two elements that are liquid at normal temperatures. Bromine is found principally in seawater, salt lakes, and underground brines associated with oil. In 2004, the quantity of bromine sold or used in the United States was 222 million kilograms (Mkg) valued at $191 million (table 1). The average value of bromine sold or used was $0.86 per kilogram (table 1). Primary uses of bromine compounds were in flame retardants (FR), drilling fluids, brominated pesticides (mostly methyl bromide), and water-treatment chemicals. World production of bromine, in descending order and percentage of total, for 2004 was estimated to be as follows: United States, 40%; Israel, 37%; China, 8%; United Kingdom, 6%; and other countries, 9% (table 5). Because of depleting reserves, distribution and economics, environmental constraints, and the emergence of Israel as the world's second ranked producer, the U.S. portion of world production had decreased steadily since 1973 when the United States produced 71% of the world's supply.

Legislation and Government Programs

The cost of security and the price of natural gas had a depressing effect on the U.S. chemical industry, including bromine. The leading end use for bromine is in FRs that are used in plastic products. Natural gas used for electrical energy generation and heating competed with gas used in manufacturing plastics. During 2004, prices for petroleum and natural gas continued to increase and the chemical industry called for a domestic energy policy.

The pesticide methyl bromide was listed as a class I ozone-depleting substance in the 1990 Clean Air Act (CAA) and had been scheduled to be phased out of use in the United States by January 1, 2001. The U.S. Congress extended the deadline until January 1, 2005, to coincide with the deadline for phaseout of methyl bromide for developed countries under the Montreal Protocol on Substances That Deplete the Ozone Layer. Domestically, methyl bromide had proven to be difficult to replace because of its low cost and usefulness against a large variety of agricultural pests.

Under the Montreal protocol, developing countries had until 2015 to phase out methyl bromide production. Countries may request exemptions from phaseout requirements for uses where there are no feasible technical or economical alternatives. The United States made a formal request to the Ozone Secretariat of the United Nations to allow use of methyl bromide after the January 1, 2005, phaseout deadline. On November 26, the Technology and Economic Assessment Panel of the United Nations approved the exemption request for some U.S. crops (Chemical & Engineering News, 2003). The United States and 11 other developed countries were approved to continue to use the fumigant in 2005 as agreed by negotiators for the Montreal protocol who meet in Prague, Czech Republic, on November 26. Under the agreement reached, the United States is allowed to use methyl bromide at 37% of its 1991 baseline level in 2005 and at 27% in 2006 (Chemical & Engineering News, 2004b).

Methyl bromide was being used for anthrax decontamination. The Environmental Protection Agency's (EPA) Technology Innovation Office was leading the effort to collect and disseminate information about technologies that detect and kill anthrax and other biological agents (U.S. Environmental Protection Agency, 2004§[1]).

The major use of bromine is as a FR material that can be added to petroleum-based products to make them resist fire. The State of California enacted laws that require upholstered furniture to resist ignition by small open flames, such as matches and cigarettes. During 2004, the Consumer Product Safety Commission (CPSC) focused on developing a regulation to address the flammability of upholstered furniture, the leading cause of residential fire deaths. A briefing package was expected to be forwarded by the staff for the commissioner's consideration in early 2005 (Consumer Product Safety Commission, 2004a§). On November 1, the CPSC announced a nationwide draft flammability standard for all mattresses sold in the United States, which follows the new California TB 603 standard in most respects. The commissioners voted unanimously on December 21 to issue a proposed safety standard to reduce deaths and injuries from fires involving mattresses. The proposed standard for mattresses addresses fires ignited by an open flame (Consumer Product Safety Commission, 2004b§).

The Centers for Disease Control and Prevention published "Facts About Bromine" on its emergency preparedness and response Web site, including facts about exposure to bromine (Centers for Disease Control and Prevention, 2004§).

In August 2003, California had banned two polybrominated diphenyl ethers (PBDE) after testing showed the chemical accumulated in humans; the ban will take effect in 2008. A third PBDE compound, which is used in plastic casings for computers and televisions and has not been shown conclusively to accumulate in humans, represents more than 95% of the PBDE used each year (Schmidt, 2004).

[1]References that include a section mark (§) are found in the Internet References Cited section.

Production

Domestic production data for bromine were developed by the U.S. Geological Survey (USGS) from a voluntary canvass of U.S. operations. Of the operations to which a canvass form was sent, seven responded, representing 100% of total U.S. elemental bromine production (table 2).

Domestic production comes from brine wells in Arkansas and Michigan. After bromine processing, the spent brine was returned underground into the production formation by class V injection wells that are regulated by the EPA. The chemical composition of the spent brine is generally similar to that of the original, except that the concentration of the target elements (such as bromine and magnesium) is reduced, and the concentration of other elements (such as calcium) may have been increased through substitution (U.S. Environmental Protection Agency, 1999). Brine in Arkansas is found in the Smackover Formation at a depth of about 2,400 meters (8,000 feet) with concentrations of 4,000 to 4,600 parts per million (ppm) bromine.

Albemarle Corporation operated the Magnolia South and Magnolia West plants in Columbia County, AR, that produced bromine and inorganic bromides and brominated FRs (BFR) and the satellite plant at Marysville, AR, in Union County that produced bromine. In addition, it maintained two facilities at Baton Rouge, LA, to conduct research and product development and to produce additives, catalysts, and FR. Albemarle announced that the active brine rights and leasing program was expected to provide the company with 40 years of proven bromine reserves. Albemarle announced investments that decreased waste generated at the Magnolia operation by 816,000 kilograms (kg) to 308,000 kg (by 1.8 million pounds to 680,000 pounds) on byproduct waste stream going to landfill (Albemarle Corporation, 2004§).

Great Lakes Chemical Corp. continued production of bromine from brines at plants in Union County, AR. Production was from the Central, Newell, South, and West plants. At yearend, the installation of a new well for the extraction of elemental bromine was announced. The company also owned Associated Octel Co. Ltd. of the United Kingdom, which produced bromine from seawater. Great Lakes phased out production of two controversial PBDE FR, penta- and octa-bromodiphenyl ether (BDPE), at yearend 2004. It developed a replacement that does not persist in the environment, does not bioaccumulate, and is not toxic. The replacement was designated for use in polyurethane foam applications, such as furniture cushions, where penta-BDPE had been used. Production of the replacement was scaled up by Great Lakes by yearend 2004.

Consumption

The USGS did not collect consumption data on bromine compounds. Apparent consumption of bromine in the United States, calculated by the USGS from production, exports, and imports, increased to an estimated 224 Mkg, a 7% increase. The United States was the world's leading market for bromine.

Flame Retardants.—It was estimated that about 50% of the consumption of bromine was used in BFRs chemicals commonly used in many domestic and industrial appliances and such equipment as computers, furniture, insulation boards, mattresses, mobile phones, televisions, and many others. About 90% of electrical and electronic appliances contain BFRs to increase their resistance to fire. BFRs are also used in textiles for upholstered furniture.

Healthcare.—A major use of bromine compounds was in the manufacture of pharmaceuticals. Brominated substances are important ingredients of many over-the-counter and prescription drugs, including analgesics, antihistamines, and sedatives. Some of the bromine drugs have proved effective in the treatment of cocaine addiction and pneumonia.

Photography.—Bromine compounds are used to make the light-sensitive component of a photographic emulsion. Other bromine compounds are used in ingredients in photographic development.

Petroleum.—Bromine compounds are used as a constituent of antiknock fluid in leaded fuel still used in small aircraft, farm equipment, and in third world countries.

Calcium bromide, sodium bromide, and zinc bromide, collectively referred to as clear brine fluids (CBFs), were used in the oil- and gas-well drilling industry for high-density, solids-free completion, packer, and workover fluids to reduce the likelihood of damage to the well bore and productive zone. TETRA Technologies, Inc. was one of the leading users of CBFs in the world. Calcium bromide and zinc bromide were purchased by TETRA from two domestic manufactures and one foreign manufacturer. TETRA also recycled calcium- and zinc-bromide CBFs repurchased from its oil and gas customers. Its West Memphis, AR, facility produced calcium bromide and zinc bromide. TETRA began operation of an elemental-bromine, calcium-bromide, and sodium-bromide plant at The Dow Chemical Company's Ludington, MI, facility in mid-1998, using purchased crude bromine from Dow's calcium-magnesium chemicals operation. TETRA also owned a plant in Magnolia, AR, which was designed to produce calcium bromide but was not operational in 2004. Approximately 33,000 gross acres (13,400 hectares) of bromine-containing brine reserves are under lease by the company (TETRA Technologies, Inc., 2005§).

Sanitary Preparations.—Bromine compounds are effective pesticides, used both as soil fumigants in agriculture, particularly fruit growing, and as a fumigant to prevent pests from attacking stored grain and other produce. Significant volumes of world trade in agriculture goods depend on the use of bromine compounds to ensure compliance with mandatory rules on quarantine. Bromine compounds are also used as intermediates to make other agriculture chemicals.

Use of pesticides, including methyl bromide, on crops in California increased in 2003 (the latest year for which data were available) compared with 2002 as follows: applied to almonds, 1.4 million pounds; strawberries, 1 million pounds; carrots, 800,000 pounds; and rice, 500,000 pounds. Decreases in uses were as follows: for grapes, 600,000 pounds; table and raisin grapes, 600,000 pounds; structural pest control, 300,000 pounds; potatoes, 300,000 pounds; and lemons, 200,000 pounds. Analyses have shown that pesticide use varies from year to year depending on acreage, economics, pest problems, types of crops planted, weather, and other factors. During 2003, pest problems were higher because of a wet and cool spring (Brank, 2005).

One of the major uses of bromine is as a water purifier/disinfectant as an alternative to chlorine. Brominated compounds are used for water treatment in swimming pools and hot tubs and are also used to control algae and bacterial growth in industrial processes.

Transportation

Bromine in bulk quantities is transported in the United States in 7,570- and 15,140-liter (L) lead-lined pressure tank cars or 6,435- to 6,813-L nickel-clad pressure tank trailers. The trailers must be filled at least 92% full to prevent inertia effects of the heavy liquid while on the highway. International shipments by The Dead Sea Bromine Group (DSBG) are in 15.2- to 23.3-metric ton (t) lead-lined tank containers (isotanks) with a volume of 5,300 to 8,000 L. For smaller quantities, lead lined tanks ("goslars") of 3.5 t (four tanks packed on one isoframe) and cylinders of 400 kg are used. Dry nitrogen gas is recommended for use in pressure transferring bromine, although dry air may be used. The gas used must be absolutely dry or severe corrosion results. When exposed to a high-humidity atmosphere, the water content of bromine can exceed 300 ppm. If the water content increases above 70 ppm, then the corrosiveness of bromine to many metals increases. Fluorinated plastics are widely used in equipment, gaskets, piping, and valves (Grinbaum and Freiberg, 2001§).

Prices

Yearend 2004 U.S. bromine prices were 19% higher than those at yearend 2003. The increases were because of the increases in the cost of energy, key raw materials, and transportation. The price, however, was not back to yearend 2000 levels, which were historically high because of demand in electronics.

The export value of elemental bromine decreased by 33% since yearend 2003. The export value of bromine compounds, including ethylene dibromide and methyl bromide, increased by 17% since yearend 2003.

The import value of elemental bromine increased by 38% compared with 2003 levels. The import values of bromine compounds decreased, except for potassium bromide and other bromide compounds, which increased by 49% and 2%, respectively. DSBG announced price increases for its major BFR products (Dead Sea Bromine Group, The, 2003).

World Review

European Union.—The European Union (EU) directive on waste electrical and electronic equipment (WEEE) will require recycling of most electrical and electronic (E&E) equipment in Europe. Polymer producers of high-impact polystyrene and acrylonitrate-butadiene-styrene are likely to be the most affected because much of the E&E market is not accessible without the use of halogenated FR (HFR), such as BFR, because of fire safety demands. To ban the use of HFRs could require prohibitively large investments in new processing equipment owing to individual polymer reliance on BFRs to meet the desired fire safety standards. The directive required the separation of at least 4 kg of WEEE per inhabitant per year by December 31, 2006. The directive gave producers a clear guarantee that no individual EU member state will be able to introduce separate bans or restrictions on any substance other than those specified in the directive (Bromine Science and Environmental Forum, 2003§).

The EU's directive on reduction of hazardous substances will take effect in 2006, mandating that electronics manufacturers switch to lead-free solder systems. These systems typically run at temperatures between 30° and 50° C higher than traditional lead systems, forcing manufacturers to make internal components with higher thermal stability. Great Lakes announced that tests of 1-di-bromostyrene FR in electronics applications show superior results in lead-free solder systems (Advanced Materials & Processes, 2005).

Israel.—DSBG is the world's leading producer of elemental bromine and a leader in the development and supply of bromine compounds. DSBG consists of four divisions that include industrial chemicals, FR, soil treatment, and biocides. Its manufacturing facilities are located in China, Israel, the Netherlands, and the United States. DSBG is a member of Israel Chemical Ltd., which includes Dead Sea Works, which controls potash and salt, and Rotem, which controls fertilizers.

Japan.—Great Lakes and Japan's Teijin Chemicals planned a joint venture to be 50% owned by each company and headquartered in Japan. Great Lakes will be the exclusive marketer of the product that will be made in El Dorado, AR, and Matsuyama, Japan (Chemical & Engineering News, 2004a).

Jordan.—At Safi, a bromine and derivatives and FR plant that produced bromine from the Dead Sea was leased by Jordan Bromine Co. Ltd. (a joint venture owned 50% by Arab Potash Co. and 50% by Albemarle) (Albemarle Corporation, 2004§).

Tajikistan.—In the southwest of the country, there are accumulations of underground mineralized water with concentrations of boron, bromine, iodine, lithium, and strontium. The Tut-Bulak deposit, 3.5 kilometers (km) east of Yavan and 13 km from the Yavansk Chemical Combine, reported values of brine containing 168 ppm bromine. Technical evaluation of one cubic meter of the brines reported the possibility of 194 t of iron bromide (Engineering News, 2004).

Current Research and Technology

A dynamic multimedia model was used to evaluate parameters relating to the environment and transportation and to assess the historical behavior and potential future of PBDEs in the Baltic region. Historical emissions for the European area were estimated. Air was assumed to be the primary emission medium. The model was able to predict relative changes in environmental concentrations over time. The ban on penta- and octa-PBDE was likely to significantly reduce the European contribution to PBDE contamination in the Arctic. Conclusions were that, in order to reduce the contamination of all PBDE compounds in the Baltic environment, a ban of penta-, octa-, and deca-PBDE would be required (Palm, Brorstrom-Lunden, and Breivik, 2004).

PBDEs, which are used to make electronics, foam, and furniture fire resistant and have been banned in some countries and in California, have been found in the United States and Europe in sediments and in human blood and breast milk. Further testing is necessary to determine the source of PBDE contamination. Researchers at the University of Texas hypothesized that lipid soluble PBDE's may enter the body through the ingestion of animal fats. Samples of dairy products, fish, and meat from three national supermarket chains in Texas varied in PBDE levels. Some government sources believe that exposure is through the diet. Other data sources point to indoor air exposure as the primary route (Chemical & Engineering News, 2004d).

Further studies funded by the Pew Charitable Trusts studied ingestion as the source of contamination. Fish obtained from supermarkets were found to have higher concentrations of chemical BFRs in farmed salmon than wild salmon. The levels of BFR also varied based on location of farming. High levels in some wild fish were attributed by researchers to the fact that the wild salmon are higher on the food chain (Eilperin, 2004).

A team of University of California scientists identified a gene in terrestrial plants that controls the production of methyl halides, gaseous compounds that contribute to the destruction of ozone in the stratosphere. The identification of the gene should help researchers determine the extent to which plants emit methyl halides into the atmosphere and why certain plants increase their methyl halide emissions in high salt environments. Another study published by a graduate student at Scripps Institution of Oceanography estimated that 10% of the natural global emissions of methyl chloride and methyl bromide could be coming from salt marshes, which make up less than 0.1% of the global terrestrial surface area. Other studies had identified biomass burning, leaded gasoline combustion, fungi, and the ocean as primary sources of methyl halides (University of California, San Diego, 2004, p. 4).

The USGS reported the possibility of bromoform formation in samples tested for the National Water Quality Laboratory Schedule 1433 (laboratory codes 8033 and 8043). As of May 1, 1.0% of bromoform concentrations were reported to be higher than the EPA Drinking Water Program maximum contamination level of 3.0 micrograms per liter. Some of these extremely high results might have largely been caused by the presence of free chlorine (U.S. Geological Survey, written commun., August 8, 2003).

Using satellite imaging, researchers at the University of Bremen, Germany, found a correlation between satellite measurements of troposphere bromine oxide and frost flower coverage. The frost flowers are delicate clusters of ice crystals that form only in the below-freezing layer of concentrated brine slush and in saturated water vapor above new sea ice. The "flowers" hold three times the concentration of bromide ions compared with seawater. The researchers suspected that the flowers contribute to the increase in bromine concentrations in the troposphere at polar sunrise, which causes atmospheric reactions that lead to ozone depletion in the troposphere (Chemical and Engineering News, 2004e)

Outlook

Flame Retardants.—Bromine is used as an FR in plastics and also acts in synergy with many other materials to increase the overall effectiveness of the FR. Between 40% and 50% of domestic demand for bromine is used in FR. Although usage fluctuates along with overall cycles in the economy, assuming sustained economic growth, demand was expected to grow by 4% per year. The ban on and voluntary withdrawal of two PBDE compounds resulted in a decrease in demand for bromine between 2001 and 2004. Recycling efforts in Europe for BFR plastics in electrical usage, which is easier to recycle than some other FR compounds, may increase the demand for BFR products because they are thought to be more environmentally friendly, especially by countries concerned about recycling, such as Japan. Growth was expected to increase overall in BFR as the CPSC approves fire safety standards for upholstered furniture in the United States and if higher flammability standards are voluntarily adopted for televisions in Europe.

Healthcare.—The use of bromine in pharmaceuticals was expected to increase in antihistamines if pseudoephedrine, a key ingredient in illegal methamphetamines, is made a prescription product.

Photography.—Recent developments in digital imaging can produce electronic prints and overhead transparencies without the need for wet processing film. This would appear to cause a decrease in bromine usage in color film and film processing; however, 75% to 85% of all televised programs seen during prime time are recorded on 35-millimeter motion picture film and then transferred to videotape or laser disc for display, and the majority of feature films for movie theater presentations are shot and printed on film because film provides higher image resolution. As digital imaging technology improves and digital equipment and printers become more affordable in the next decade, future uses of bromine in film and processing may be limited to specialty film imaging.

Petroleum.—Demand for bromine as a gasoline additive has declined since the 1970s when the EPA issued regulations to reduce and eliminate lead in automotive gasoline. In 1979, the amount of bromine sold for this application had reached a peak of 225 Mkg. The rapid decline to 141 Mkg in 1986 was a direct result of the limits on lead in leaded automotive gasoline. The CAA requires mobile sources, such as cars and trucks, to use the most effective technology possible to control emissions. Newer prototypes of the fuel cell that burn gasoline can double the mileage and decrease emissions by using unleaded gasoline or other nonbrominated fuels. The use of calcium-, sodium-, and zinc-bromides as CBF as oil-well-completion and workover fluids has benefited in recent years from high gas and oil prices resulting from the increased demand for petroleum products. Increased demand for CBF was expected to continue until alternative sources of fuel become available.

Sanitary Preparations.—The growth potential remains high for bromine-base biocides for use in industrial cooling systems because of environmental restrictions on chlorine and new alkaline-base chemical treatment programs. The most common bromine compounds used in cooling water are 1-bromo-3-chloro-5,5-dimethylhydantoin and mixtures of sodium bromide with sodium hypochlorous acid. Bromine was used in indoor swimming pools, hot tubs, and whirlpools. Bromine has been found to be safer than its substitutes in sanitary preparations because bromine has a higher biocidal activity level for the same volume of product. The use of bromine compounds was expected to continue increasing in the spa and hot tub sector and to increase as a gentler disinfectant compared with chlorine in swimming pools.

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TABLE 1

SALIENT BROMINE AND BROMINE COMPOUNDS STATISTICS[1]

(Thousand kilograms and thousand dollars)

	HTS[2] number	2000	2001	2002	2003	2004
United States:						
Bromine sold or used:[3]						
Quantity		228,000	212,000	222,000	216,000	222,000
Value		206,000	159,000	166,000	155,000	191,000
Apparent consumption		238,000	214,000	216,000	210,000	224,000
Exports:[4, 5]						
Elemental bromine:	2801.30.2000					
Quantity		1,870	3,710	6,070	2,280	2,840
Value		2,560	3,600	4,680	3,090	2,070
Bromine compounds:[6]	(7)					
Gross weight		9,210	7,990	8,000	7,160	7,850
Contained bromine		7,740	6,740	6,750	6,040	6,600
Value		26,200	14,900	13,600	11,800	13,800
Imports:[4, 8]						
Elemental bromine:	2801.30.2000					
Quantity		5,470	5,610	2,020	1,920	2,650
Value		3,730	4,240	1,530	1,450	2,000
Bromine compounds:						
Ammonium bromide:	2827.59.2500					
Gross weight		48,100	59,700	16,900	46,600	3,310
Contained bromine		3,930	4,870	1,380	3,800	2,700
Value		22,000	29,200	8,850	21,100	1,520
Calcium bromide:	2827.59.2500					
Gross weight[9]		7,860	5,880	164	9	--
Contained bromine		6,280	4,700	131	7	--
Value		4,780 e	3,580 e	100 e	4 e	--
Potassium bromate:	2829.90.0500					
Gross weight		245	124	126 [9]	131 [9]	54
Contained bromine		117	59	36	63	26
Value		1,100	450	457 e	475 e	163
Potassium bromide:[10]	2827.51.0000					
Gross weight		871 [9]	433 [9]	171 [9]	497	598 [9]
Contained bromine		585	291	115	334	401
Value		2,130	1,060 e	417 e	1,210 e	1,800 e
Sodium bromate:	2829.90.2500					
Gross weight		1,160	1,020	1,020	967	992
Contained bromine		615	538	539	512	525
Value		2,750	2,190	2,020	2,010	1,930
Sodium bromide:[10]	2827.51.0000					
Gross weight[9]		3,130	NA	2,980 [9]	3,670 [9]	4,610 [9]
Contained bromine		2,430	NA	2,320	2,940	3,580
Value		4,820 e	NA	4,600 e	5,660 e	5,300 e
Other compounds:						
Gross weight		7,760	5,950	4,920	3,280	4,630
Contained bromine		582	141	176	246	347
Value		15,500	5,360	6,090	19,000	19,400
World, production e		542,000	523,000	540,000	548,000	556,000 e

See footnotes at end of table.

TABLE 1—Continued

SALIENT BROMINE AND BROMINE COMPOUNDS STATISTICS[1]

[e]Estimated. NA Not available. -- Zero.

[1]Data are rounded to no more than three significant digits.

[2]Harmonized Tariff Schedule of the United States (HTS).

[3]Elemental bromine sold as such to nonproducers, including exports, or used by primary U.S. producers in preparing bromine compounds.

[4]Source: U.S. Census Bureau.

[5]Export values are free alongside ship.

[6]Source: U.S. Census Bureau. Includes methyl bromine and ethylene dibromide.

[7]Data for these compounds are derived from HTS number 2903.30.0500 (2001, 2002 and 2004), and 2903.30.1520 (2000, 2002, 2003, and 2004) information.

[8]Import values are cost, insurance, and freight.

[9]Source: The Journal of Commerce Port Import/Export Reporting Service.

[10]"Potassium bromide" and "Sodium bromides" import data are usually reported by a mutual HTS number, 2827.51.0000.

TABLE 2
ELEMENTAL-BROMINE-PRODUCING PLANTS IN THE UNITED STATES IN 2004

State and company	County	Plant	Production source	Capacity[1] (million kilograms)
Arkansas:				
Albemarle Corporation	Columbia	Magnolia (a)	Well brines	148 [2]
Do.	do.	Magnolia (b)	do.	
Do.	Union	Satellite plant	do.	
Great Lakes Chemical Corporation	do.	El Dorado (a)	do.	
Do.	do.	El Dorado (b)	do.	71 [2]
Do.	do.	Marysville	do.	36
Do.	do.	Newell	do.	23
Michigan, The Dow Chemical Company	Mason	Ludington[3]	do.	9
Total				287

[1]Actual production capacity is limited by brine availability.
[2]This represents the cumulative capacity of the three identified plant sites.
[3]Bromine produced at this plant is reprocessed in Arkansas.

TABLE 3
U.S. IMPORTS OF OTHER BROMINE COMPOUNDS[1, 2]

Compound	HTS[3] number	2003 Gross weight (kilograms)	2003 Value[4] (thousands)	2004 Gross weight (kilograms)	2004 Value[4] (thousands)	Principal sources, 2004
Hydrobromic acid	2811.19.3000	215	$255	753	$543	Israel, 99%.
Ethylene dibromide	2903.30.0500	88	100	548	395	Israel, 92%, United Kingdom, 8%.
Methyl bromide	2903.30.1520	356	1,220	821	2,690	Israel, 100%.
Dibromoneopentyl glycol	2905.50.3000	1,140	3,800	995	3,260	Israel, 99%.
Tetrabromobisphenol A	2908.10.2500	452	1,020	658	1,800	Israel, 90%, China, 5%, other, 5%.
Decabromodiphenyl oxide and octabromodiphenyl oxide	2909.30.0700	3,300 [5]	6,210 [e]	4,360	8,080 [e]	Israel, 98%, China, 2%.
Total		5,460	12,600	8,130	16,800	

[e]Estimated.

[1]These data detail the information included in table 1 under "Imports, bromium compounds, other compounds."

[2]Data are rounded to no more than three significant digits; may not add to totals shown.

[3]Harmonized Tariff Schedule of the United States.

[4]Declared cost, insurance, and freight valuation.

[5]Source: The Journal of Commerce Port Import/Export Reporting Service.

Source: U.S. Census Bureau.

TABLE 4

WORLD BROMINE ANNUAL PLANT CAPACITIES AND SOURCES AS OF DECEMBER 31, 2004[1]

Country and company or plant	Location	Capacity (thousand kilograms)	Source
Azerbaijan, Neftechala Bromine Plant	Baku	4,000	Underground brines.
China, Laizhou Bromine Works	Shandong	43,000	Do.
France, Albemarle	Port-de-Bouc	15,000	Seawater.
India:			
Hindustan Salts Ltd.	Jaipur	NA	Seawater bitterns from salt production.
Mettur Chemicals Ltd.	Mettur Dam	NA	Do.
Tata Chemicals Ltd.	Mithapur	NA	Do.
Total		1,500	
Israel, Dead Sea Bromine Co. Ltd.	Sdom	190,000	Bitterns of potash production from surface brines.
Italy, Societa Azionaria Industrial Bromo Italiana	Margherita di Savoia	900	Seawater bitterns from salt production.
Japan, Toyo Soda Manufacturing Co. Ltd.	Tokuyama	20,000	Seawater.
Jordan, Jordan Bromine Co. Ltd.	Safi	50,000	Bitterns of potash production from surface brines.
Spain, Derivados del Etilo S.A.	Villaricos	900	Seawater.
Turkmenistan:			
Nebitag Iodine Plant	Vyshka	3,200	Underground mines.
Cheicken Chemical Plant	Balkan	6,400	Do.
Ukraine, Perekopskry Bromine Plant	Krasnoperckopsk	3,000	Do.

[1]Excludes U.S. production capacity, which is detailed in table 2.

TABLE 5

BROMINE: ESTIMATED WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Thousand kilograms)

Country[3]	2000	2001	2002	2003	2004
Azerbaijan	2,000	2,000	2,000	2,000	2,000
China	42,000	40,000	42,000	42,000	43,000
France	2,000	2,000	2,000	2,000	2,000
Germany	500	500	500	500	500
India	1,500	1,500	1,500	1,500	1,500
Israel	210,000 [4]	206,000	206,000	206,000	206,000
Italy	300	300	300	300	300
Japan	20,000	20,000	20,000	20,000	20,000
Jordan	-- [4]	-- [4]	5,000 [4]	20,000	20,000
Spain	100	100	100	100	100
Turkmenistan	150	150	150	150	150
Ukraine	3,000	3,000	3,000	3,000	3,000
United Kingdom	32,000 [4]	35,000 [4]	35,000	35,000	35,000
United States[5]	228,000 [4]	212,000 [4]	222,000 [4]	216,000 [4]	222,000
Total	542,000	523,000	540,000	548,000	556,000

-- Zero.

[1]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Table includes data available through April 12, 2005.

[3]In addition to the countries listed, several other nations, including Iran, produced bromine, but output data were not reported; available general information is inadequate to formulate reliable estimates of output levels.

[4]Reported figure.

[5]Sold or used by producers.